1200 G Street, NW • Suite 500
Washington, DC 20005
202-628-6380 Fax: 202-393-5453
Web: www.atis.org

August 26, 2005

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Office of the Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: *Ex Parte* Presentation in WT Docket No. 01-309
Section 68.4(a) of the Commission's Rules Governing Hearing Aid Compatible Telephones

Dear Ms. Dortch:

On August 26, 2005, representatives from the Alliance for Telecommunications Industry Solutions ("ATIS") Incubator Solutions Program 4 dealing with Hearing Aid Compatibility issues ("AISP.4-HAC" or "HAC Incubator") met with representatives from the Federal Communications Commission's ("FCC") Office of Engineering & Technology ("OET"). At the meeting, the HAC Incubator representatives discussed technical challenges and potential solutions for Hearing Aid Compatibility ("HAC"). This discussion was consistent with the written presentation attached to this letter.

In attendance, representing the WTB were: Fred Thomas, Chief of Staff; Patrick Forster, Senior Engineer, Policy and Rules Division; Rashmi Doshi, Chief of the Laboratory Division; Martin Perrine, Electronic Engineer, Laboratory Division. The individuals representing the AISP.4-HAC were: Steve Coston, Technical Manager, Regulatory Project Office, Sony Ericsson Mobile Communications; Mel Frerking, Director of WTS, Cingular Wireless; Al Wieczorek, Distinguished Member of the Technical Staff, Motorola; David Dzumba, Senior Manager, Nokia; James Turner, Technical Coordinator, ATIS; Martha Ciske, Committee Administrator, ATIS; and Thomas Goode, Attorney, ATIS.

Pursuant to Section 1.1206(b)(2) of the Commission's rules, one copy of this letter is being filed electronically for inclusion in the public record of the above-referenced proceeding.

If there are any questions regarding this matter, please do not hesitate to contact the undersigned.

Sincerely,

Thomas Goode
Attorney
The Alliance for Telecommunications
Industry Solutions
1200 G Street NW
Suite 500
Washington, DC 20005
Phone: (202) 434-8830

Attachment

Report of the AISP.4-HAC on Technical Issues Pertaining to Low Band Wireless Device Compliance

Long Term Solutions and
Additional Technical Data

August 24, 2005

Long Term Needs and Technical Discussion

- Necessary enhancements to the C63.19 Standard
  - Band Differences
  - Peak Power Definition
  - AWF
  - Square Law Detector

Band Differential Follow-up

- Previously 12 Hearing Aids (ITE and BTE styles) were tested with 2 GSM 850/1900 MHz wireless phones.
  - Expansion of this testing was requested by FCC and others
- Two subsequent series of tests were performed
  - Expansion of GSM sample size
  - Verification that band differential effect applies to other technologies (*i*DEN, CDMA, TDMA, AMPS)

Test Data

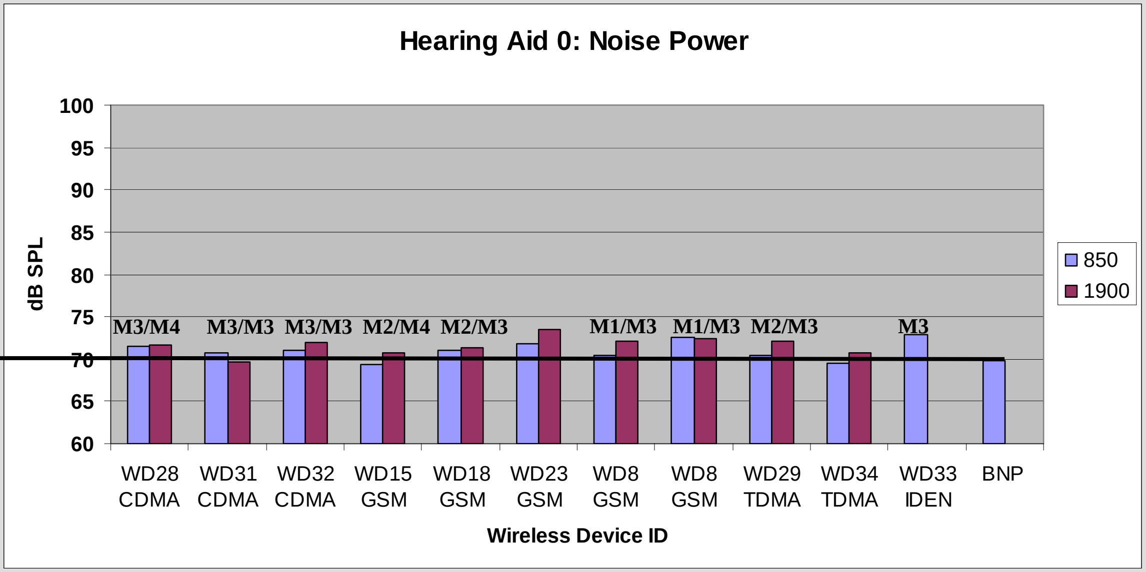
- All Wireless technologies from 8 different manufactures tested
  - 3 CDMA
  - 4 GSM
  - 1 *i*DEN
  - 2 TDMA
- 10 Hearing Aids
  - 6 BTE
  - 4 ITE
- Every phone tested against every hearing aid at 850 MHz and 1900 MHz
- Also performed AMPS test with TDMA and CDMA phones

Cell Phones

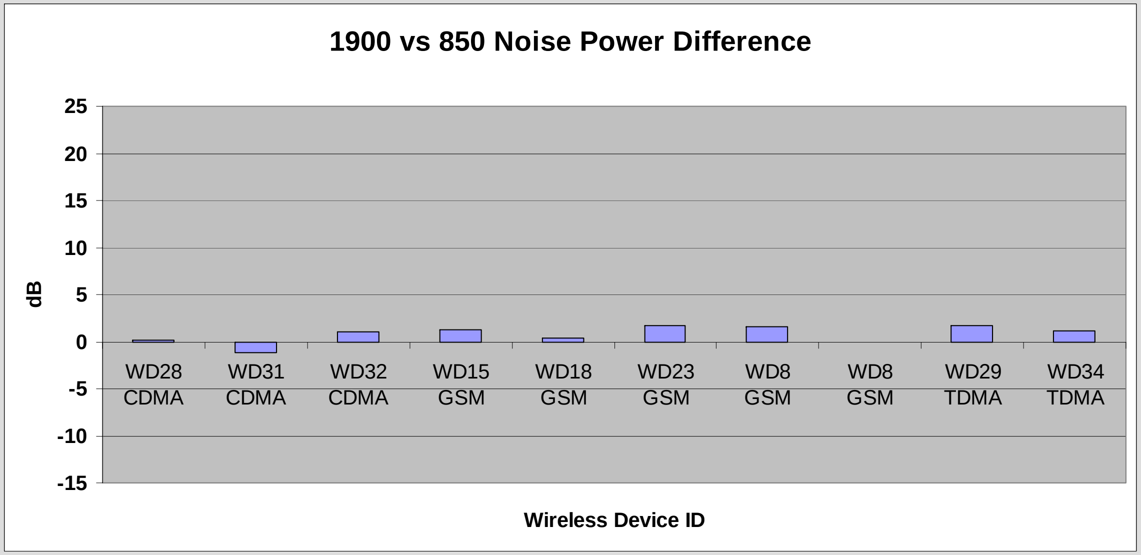
Hearing Aids

- 7 Digital
- 3 Analog
- All tested in Microphone Mode

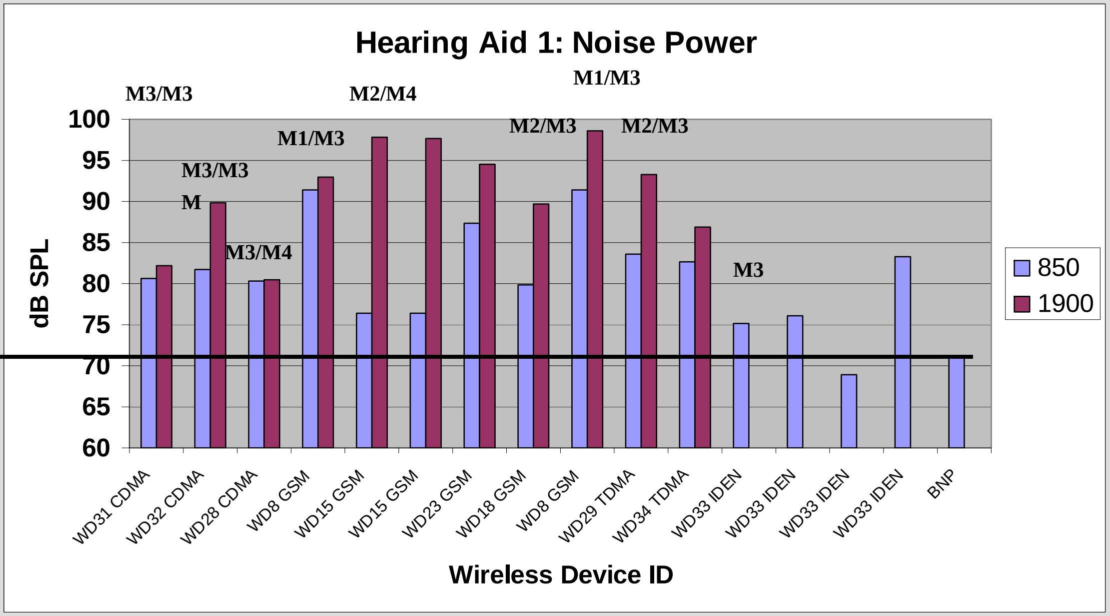
Hearing Aid #0
Digital



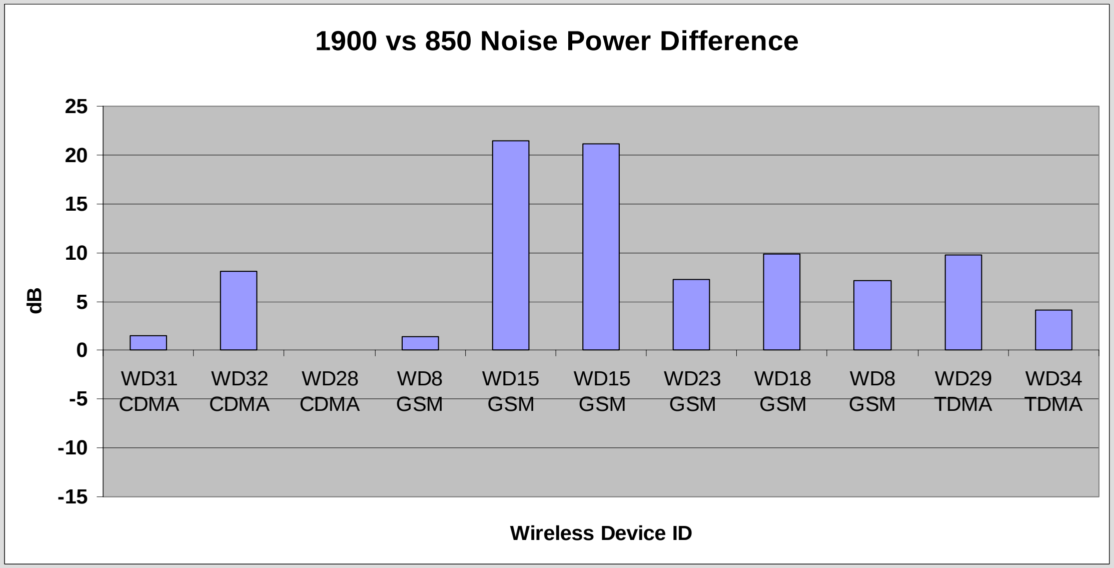
Baseline No Phone Determines Noise Floor



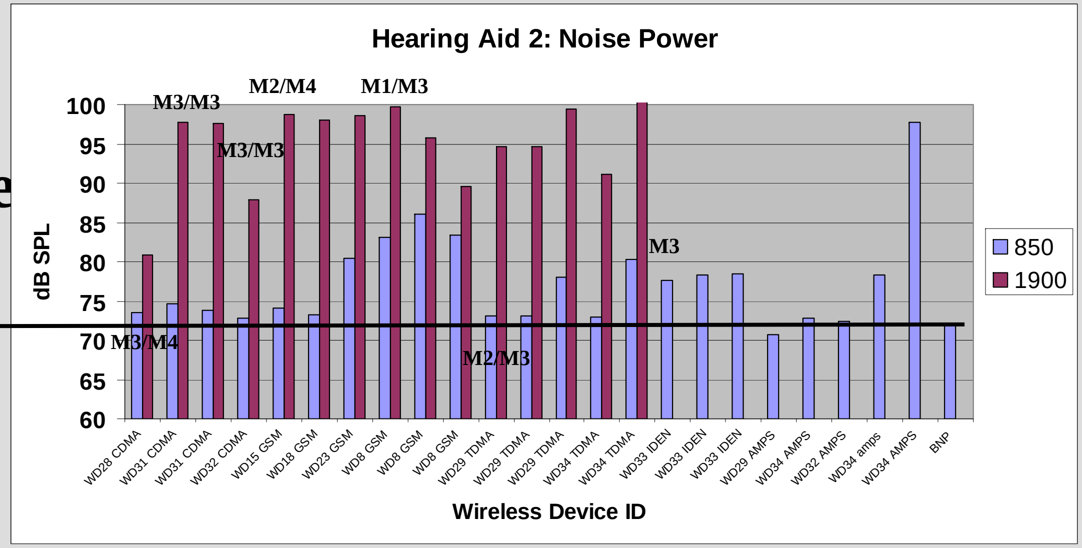
Hearing Aid #1 Analog



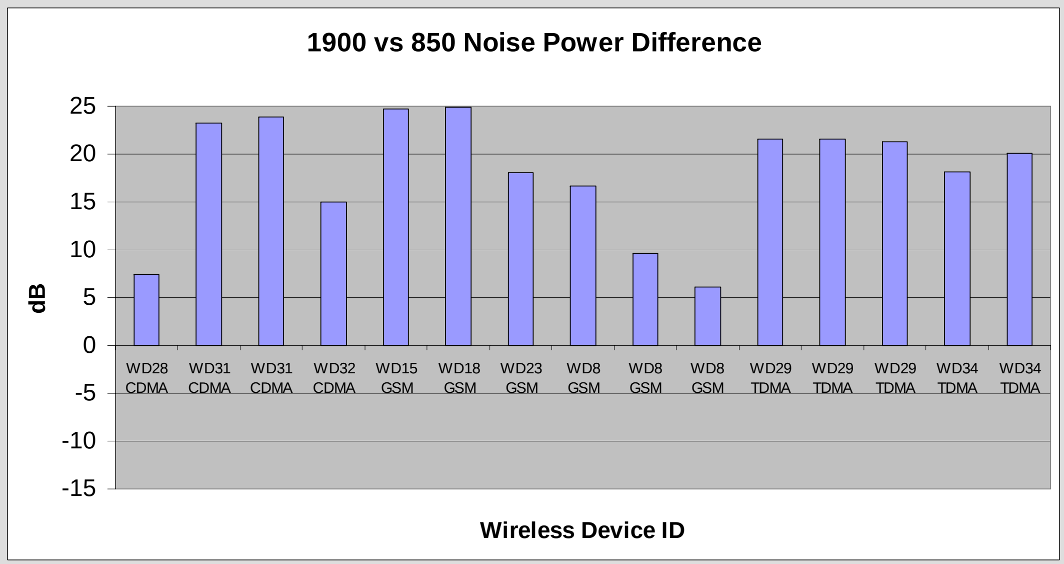
Baseline No Phone Determines Noise Floor



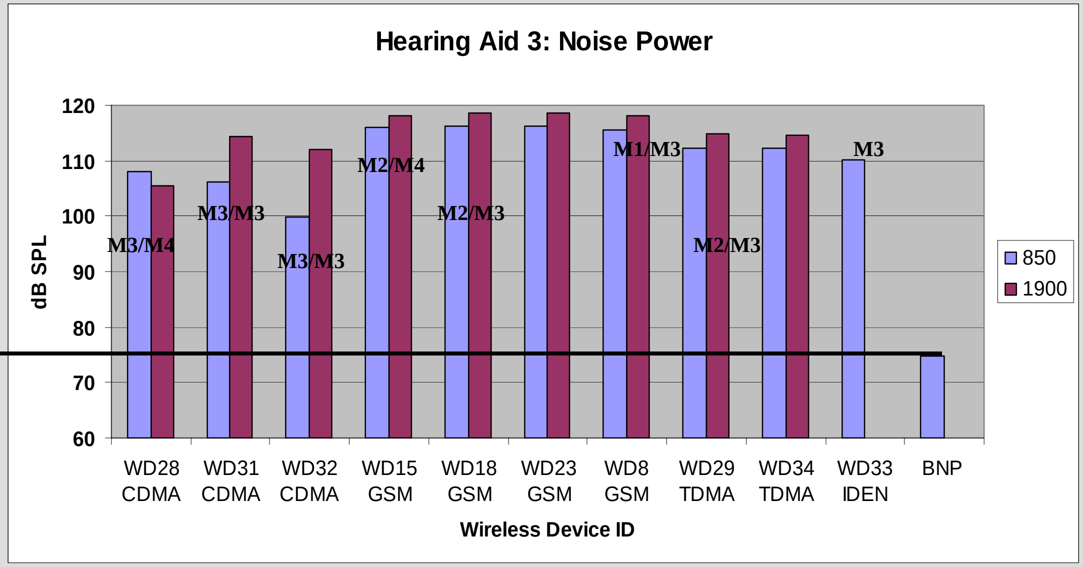
Hearing Aid #2 Analog – Digitally Programmable



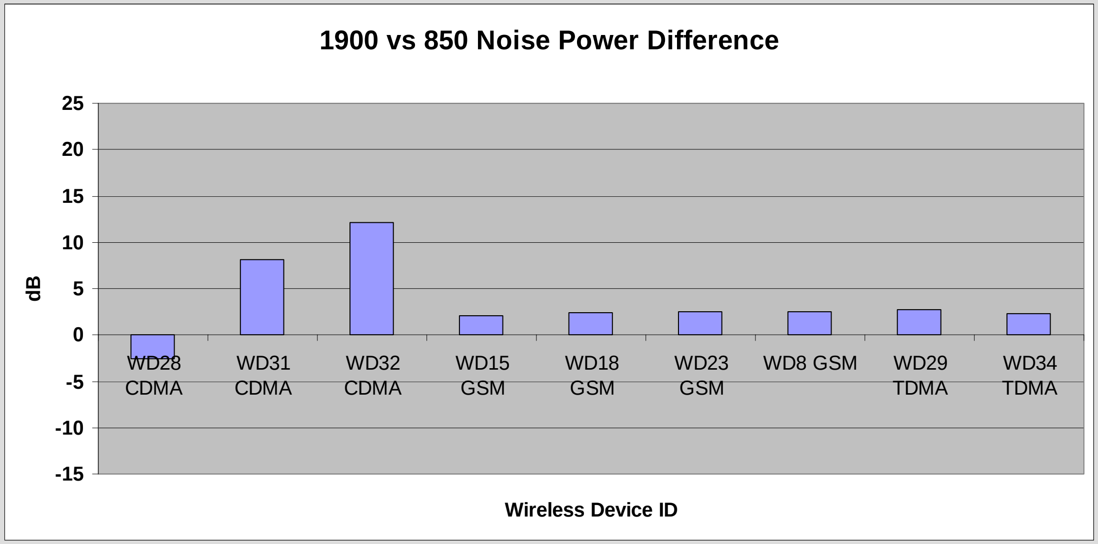
Baseline No Phone Determines Noise Floor



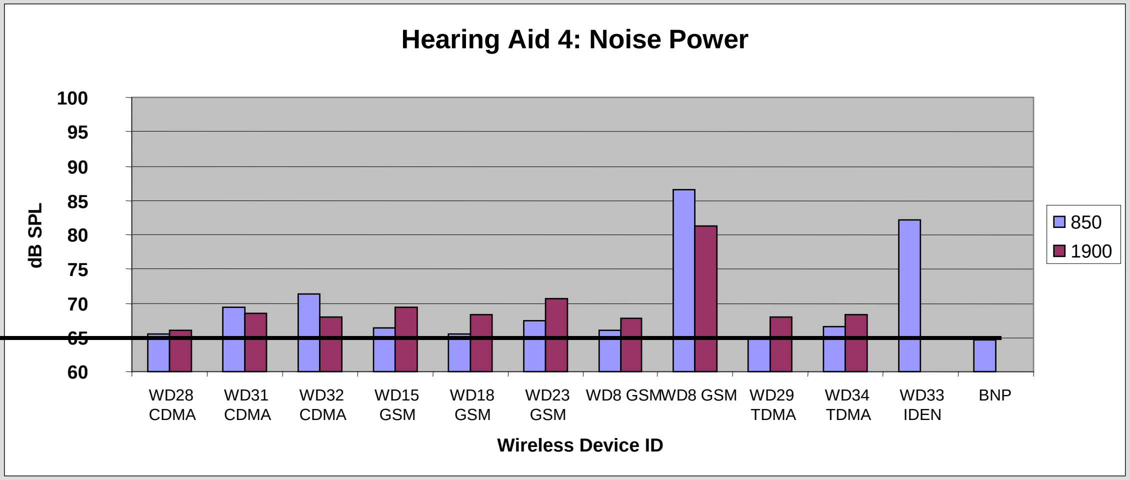
Hearing Aid # 3 Analog



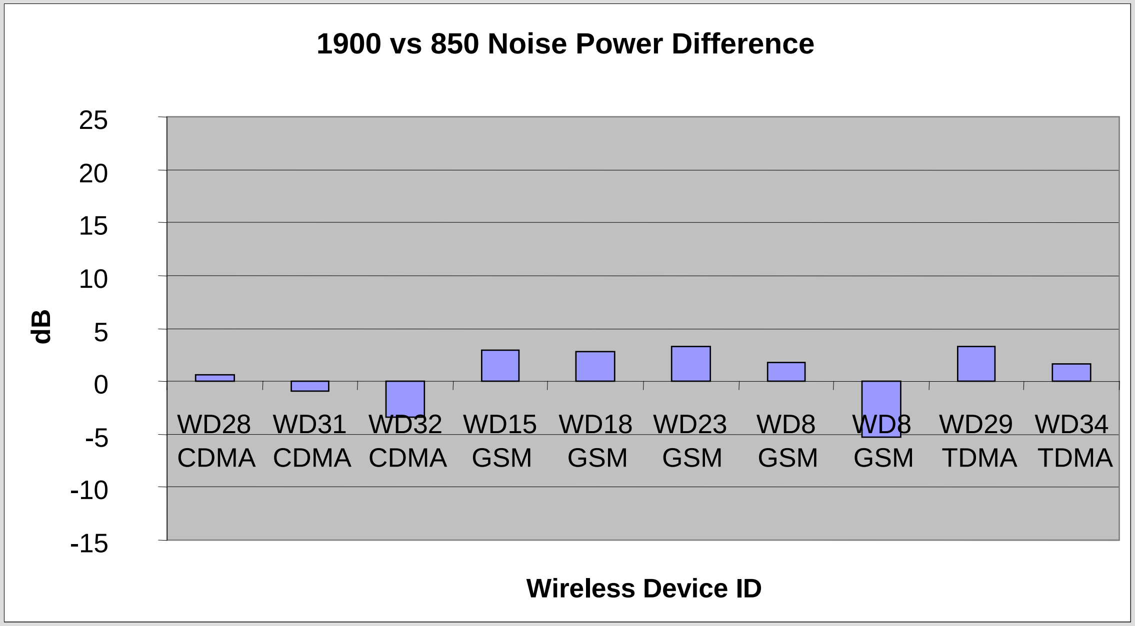
Baseline No Phone Determines Noise Floor



Hearing Aid # 4
Digital

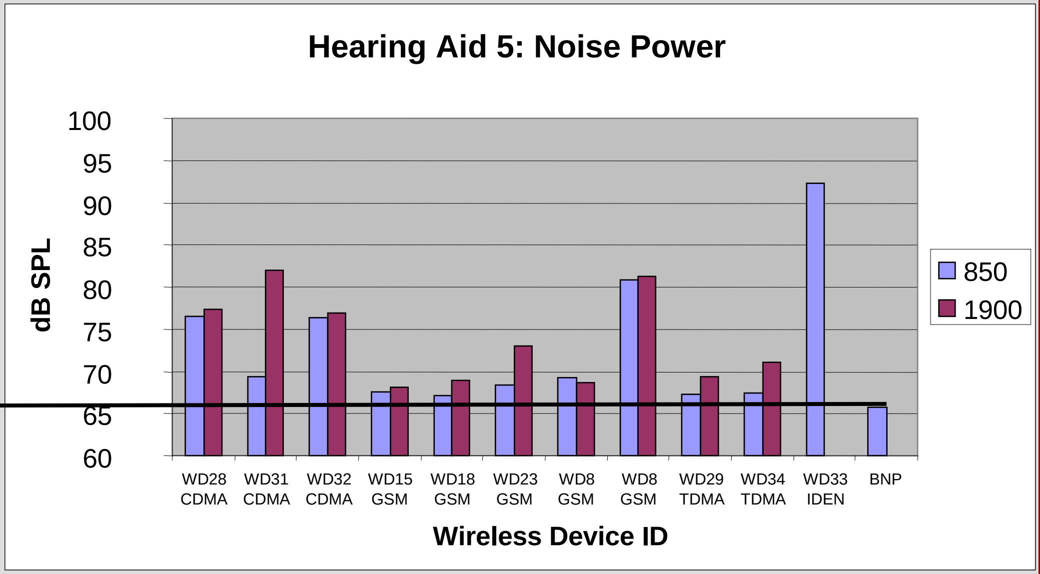


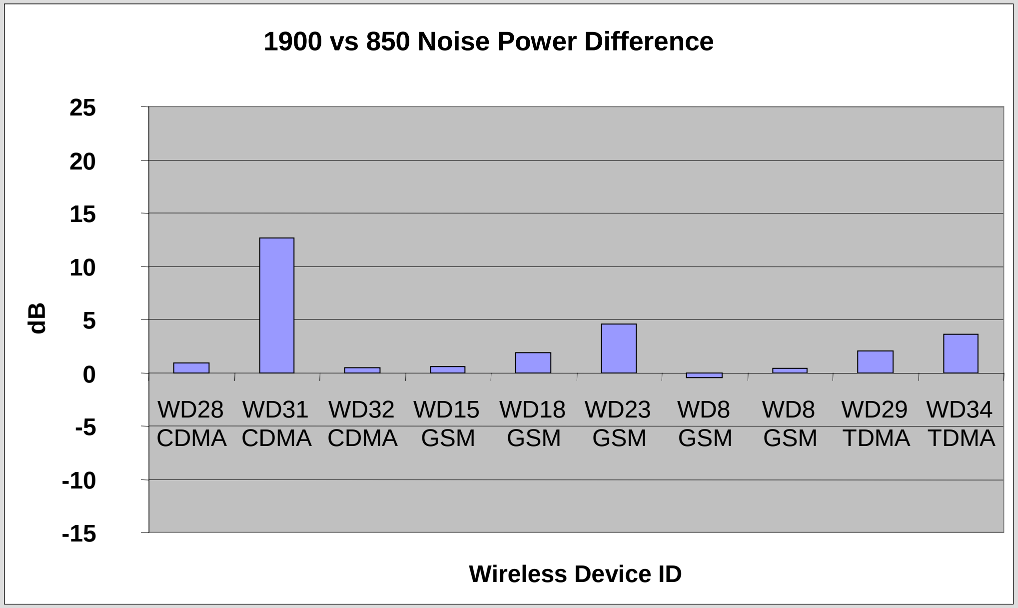
Baseline No Phone Determines Noise Floor



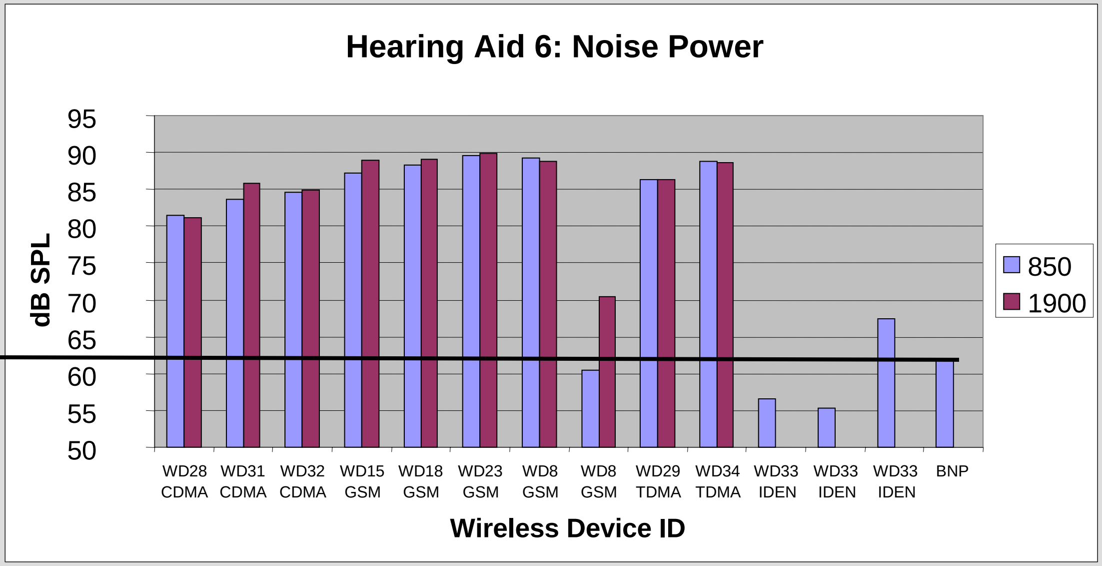
Hearing Aid # 5 Digital

Baseline No Phone Determines Noise Floor

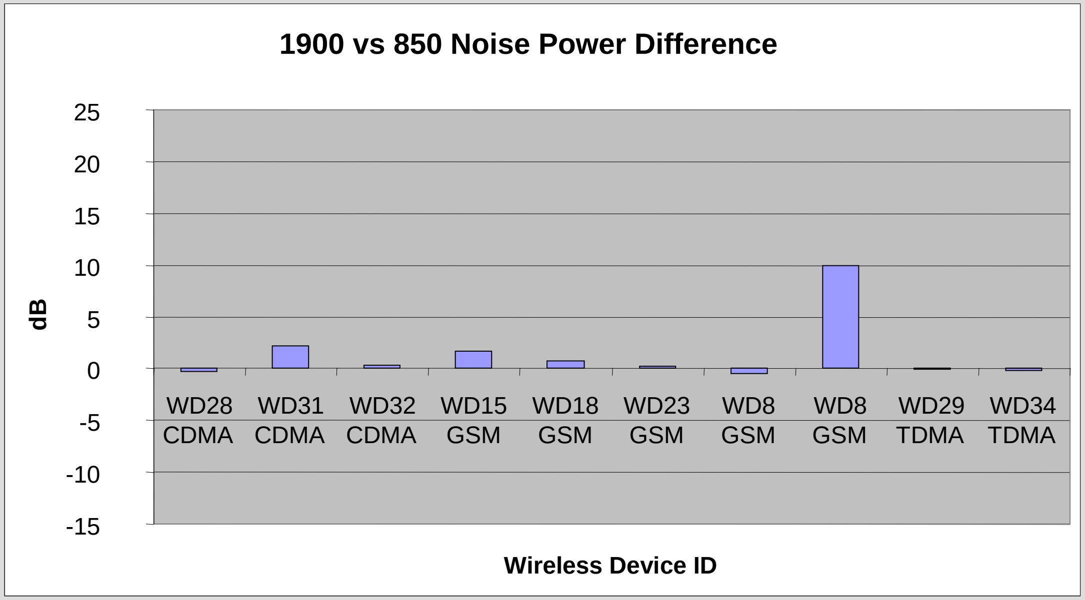




Hearing Aid # 6 Digital

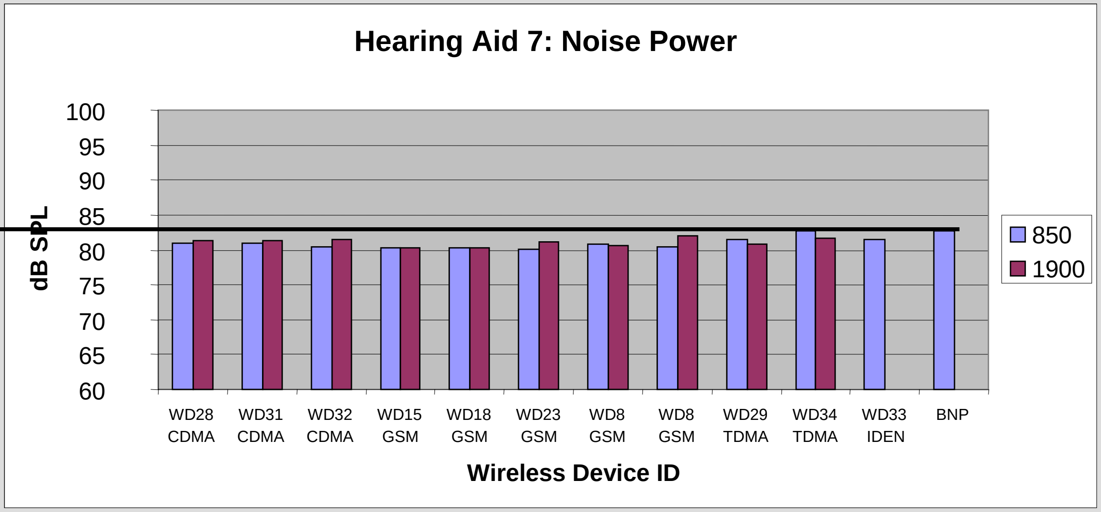


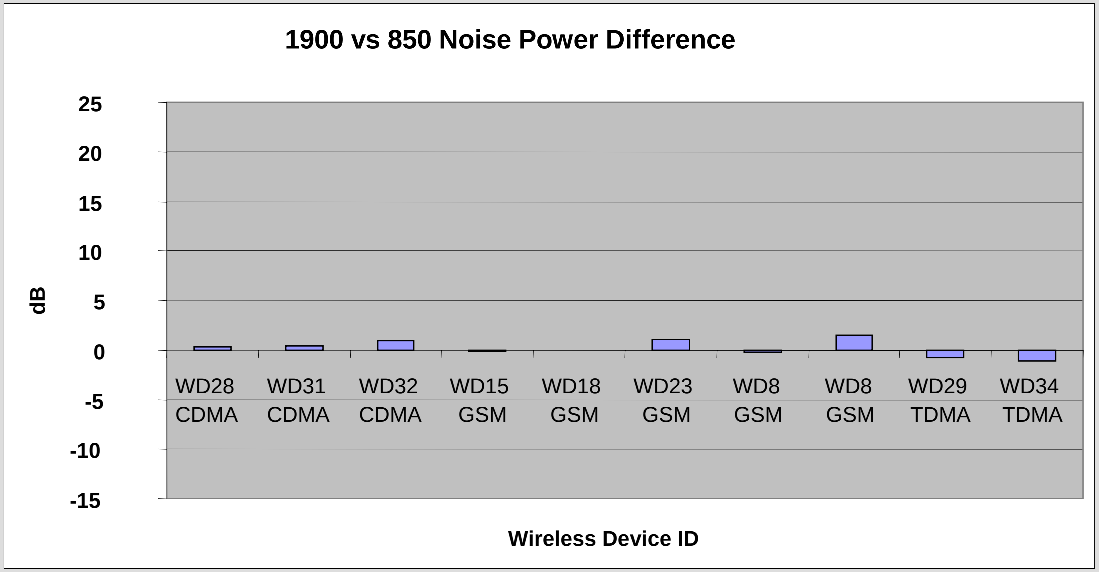
Baseline No Phone Determines Noise Floor



Hearing Aid # 7
Digital

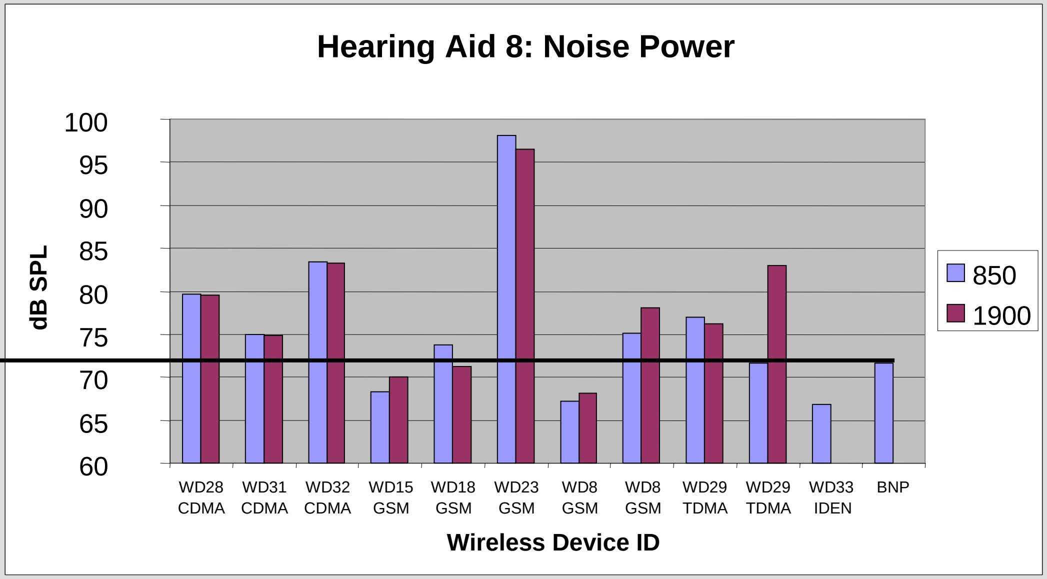
Baseline No Phone Determines Noise Floor

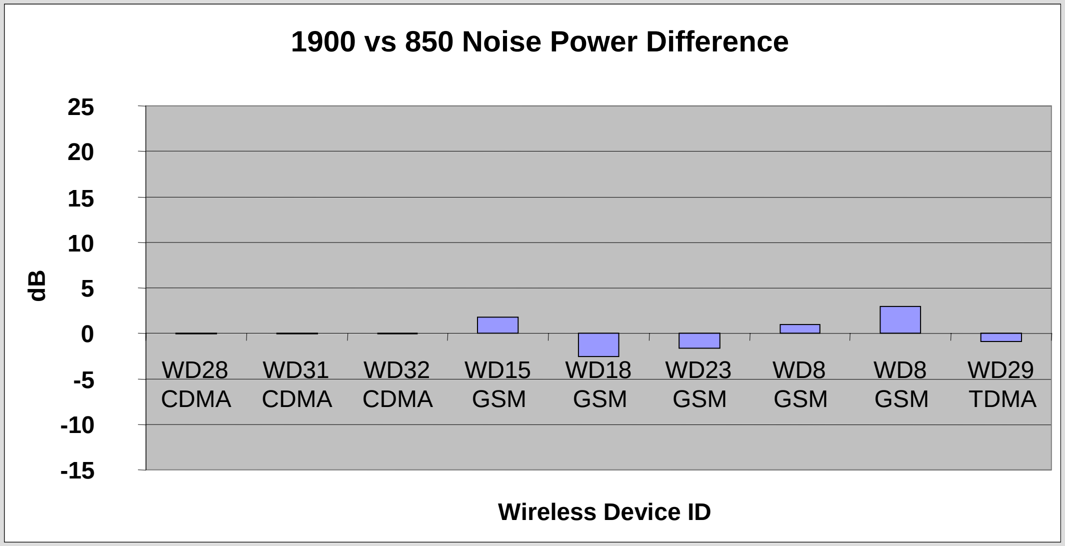




Hearing Aid #8 Digital

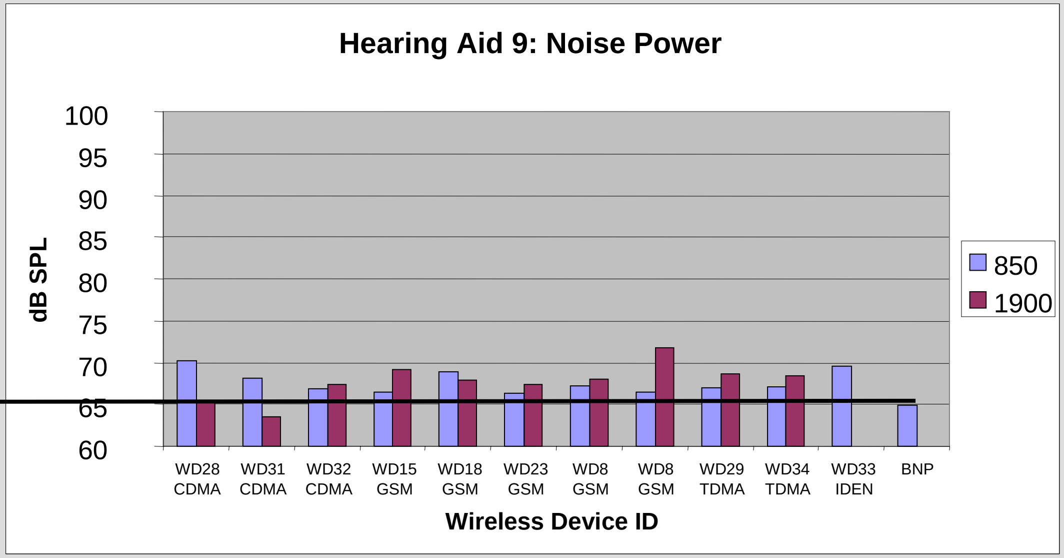
Baseline No Phone Determines Noise Floor

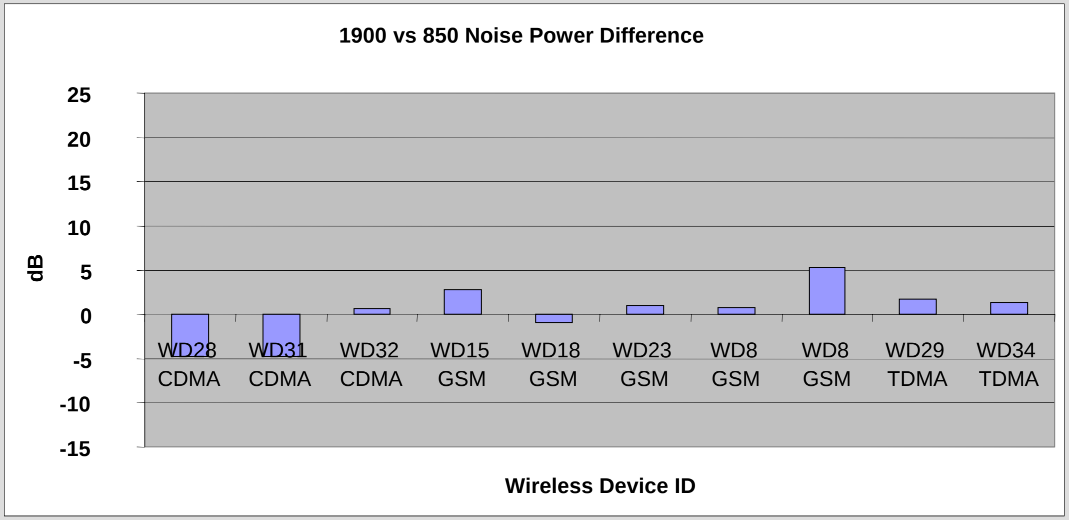




Hearing Aid # 9 Digital

Baseline No Phone Determines Noise Floor





AISP.4-HAC WG-9 Test Conclusions

Average Across Technologies

	CDMA	GSM	TDMA
Average of 1900 vs 850 Difference (dB)	8.8	9.6	10.0

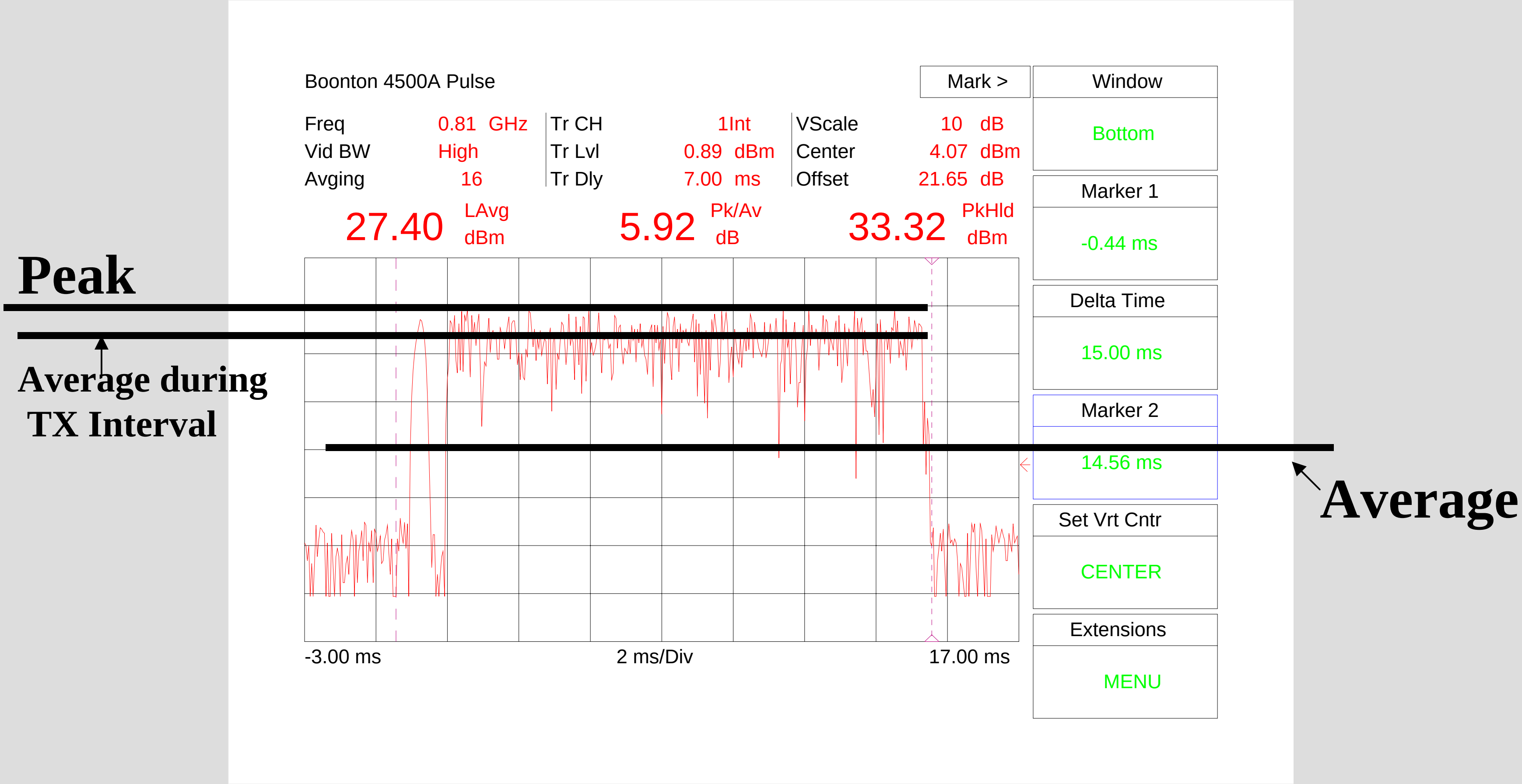
Average Across All Technologies
(Three Has that had interference
Tested with three technologies
9 data points)

Average of 1900 vs 850 Difference (dB) for CDMA, GSM, & TDMA	9.5

Peak Power Definition

- Clarity is needed in test procedures
- Agreement reached at December 2004 C63.19 meeting that test power should be average during TX interval
- Some devices will fail using absolute peak power yet are highly usable by HA consumers

Typical *i*DEN TX Waveform



AISP.4 HAC Peak Power Definition Recommendations

- Recommend that FCC provide clarity to testing by specifying definition of peak power as power averaged over the TX interval
- Recommend that FCC support AISP.4 HAC efforts to include this definition into the C63.19 Standard by December 2005

Articulation Weighting Factor

- Scientific method is needed for assignment of AWF to new technologies
  - WiFi/WiMAX
  - WCDMA (UMTS)
  - LTE
  - Bluetooth
- Efforts are underway within AISP.4 HAC WG-8 and within C63 PIN-C ad hoc to create such a method

ATIS

AISP.4 Articulation Weighting Factor Recommendations

- Recommend that FCC support efforts reflecting AISP.4 HAC WG-8 and PIN C ad-hoc recommendations on AWF to include changes to C63.19-2005

Motorola SHHH Test Results

SHHH 2005 Annual Convention

Hearing Aid Compatibility (HAC)

Interim Report

Al Wieczorek

Listening Test Overview

- Objective 1 - Compare modulation protocol effect on random users in the same (800) MHz band
- Objective 2 – Compare Motorola portfolio with subject’s current choice
- Procedure - Subjects called on-net, listened to a special prerecorded mix of a male and a female reading magazine articles, scores a value from 1 to 6 on the amount of interference they heard, switches from M to T and repeats, then listens on another unit

No Interference	Not Annoying	Mildly Annoying	Annoying	Very Annoying	Unbearable

6-----------|-----------5---------|-----------4---------|-----------3---------|-----------2---------|------------1

I do not detect any interference	I detect interference, but it is not at all annoying	The interference is slightly annoying, but I can ignore it	The interference is annoying, but not uncomfortable	The interference is very annoying, and makes it hard to concentrate	The interference is uncomfortable and intolerable, even for a short time

SHHH Subject's Hearing Instrument

	BTE (18)	IE (2)	CI (10)
CI -A			1
CI -B			5
CI -C			4
HA -A	2		
HA -B	7		
HA -C	2		
HA -D		2	
HA -E	1		
HA -F	3		

SHHH Subject's Service Provider

	Verizon (Analog)	Verizon (CDMA)	Sprint (CDMA)	Bell Mobility (CDMA)	T-Mobile (GSM)	Cingular (GSM)	Nextel (*i*DEN)
Behind the ear (BTE)		4	2	1	2	4	
In the ear (ITE)	1	1					
Cochlear Implant (CI)		2	1		2		

Cellphone Characteristics

OWN – subject's personal phone on various networks
CDMA on Verizon
*i*DEN on Nextel (now Sprint)
NADC/TDMA on Cingular
GSM on Cingular

Signal strength was generally 3 bars in Capital Conference Room of the Omni Shoreham Hotel, Washington, DC

ATIS

RF Interference – Microphone coupled

No interference

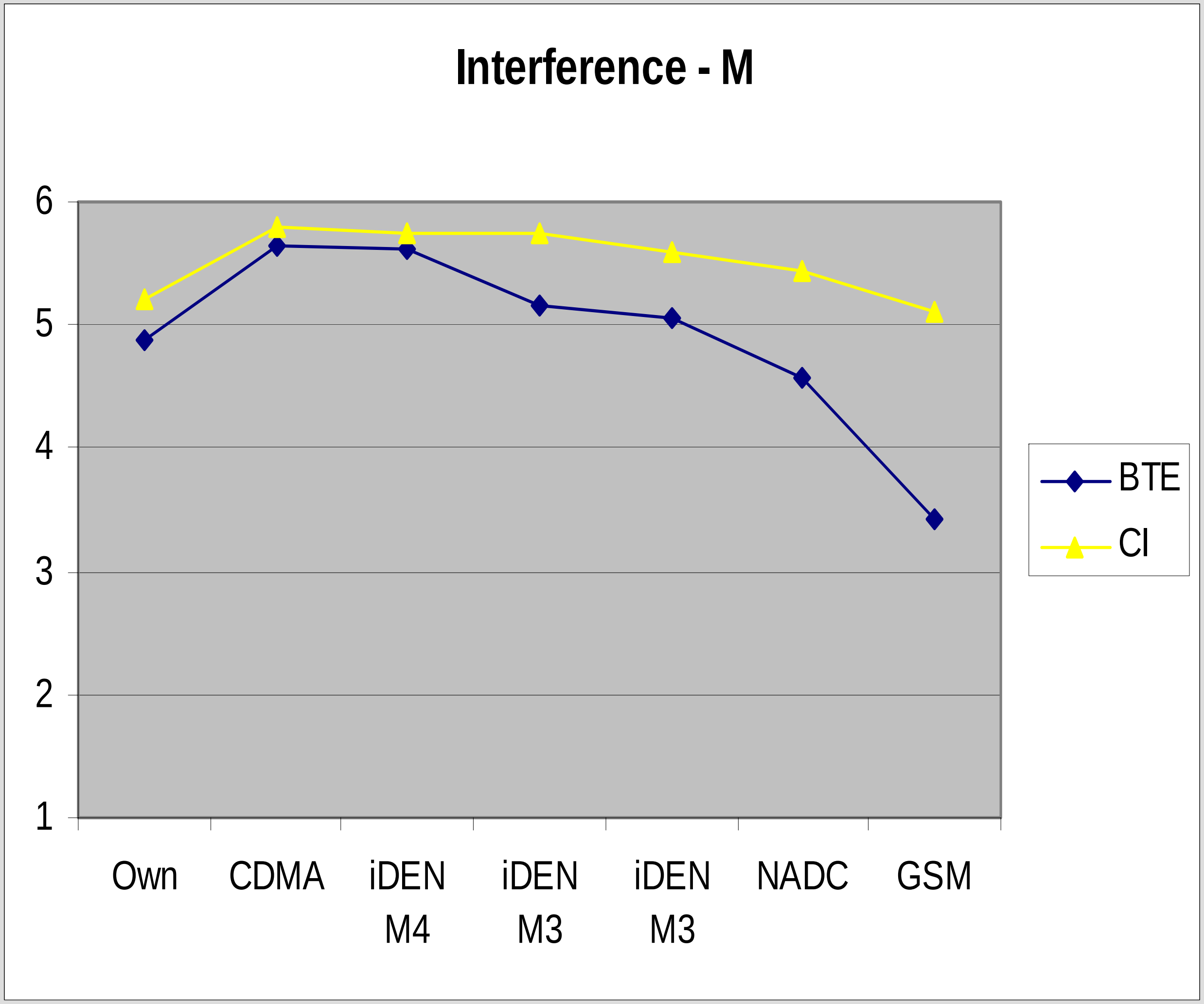
Not annoying

Mildly annoying

Annoying

Very annoying

Unbearable



Motorola SHHH-05 Summary

•Average transmission technology ratings by subjects using BTE and CI type hearing instruments exceeded:

CDMA and *i*DEN TDM	"Not annoying"
NADC (aka TDMA)	"Mildly Annoying"
GSM TDM	"Annoying"

•*i*DEN clamshell and CDMA had less interference and were more useable than BTE and CI subject's own phone using acoustic coupling

•This data demonstrates that *the user experience with iDEN wireless devices operating in the Low Band is similar to the experience of wireless devices in other air interface technologies operating in the High Band*

Square Law Applied to Hearing Aid Compatibility - Unmodulated

$$e(t) \longrightarrow \boxed{\text{Square Law Detector}} \longrightarrow \varphi(t)$$

$$\varphi = a_o + a_1 e + a_2 e^2 \qquad 1)$$

$$e_{CW} = E\cos(\omega t) \qquad 2)$$

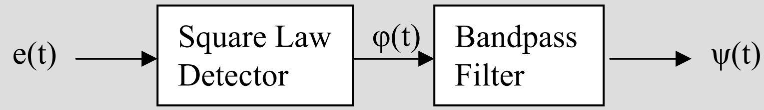
After expansion the signal is seen to consist of 2 components, a non time varying DC component equal to

$$\varphi_{CW}\,(DC) = a_o + a_2\,E2/2 \qquad 5)$$

and a time varying multiple sinusoidal AC component equal to

$$\Phi_{CW}\,(AC) = a_1\,E\cos(\omega t) + a_2\,(E2/2)\cos(2\omega t) \qquad 6)$$

Square Law Applied to Hearing Aid Compatibility – Amplitude Modulation



$e_{AM} = E\,(1 + m\cos(\mu t))\cos(\omega t)$ where $0 \le m \le 1$ 7)

$e^2_{AM} = E^2\,[(1 + 2m\cos(\mu t) + m^2(1 + \cos(2\mu t))/2]\,(1 + \cos(2\omega t))/2$ 8)

$\varphi_{AM} = a_o + a_1 E + a_2 E_2\,[(1 + m^2/2) + 2m\cos(\mu t) + (m^2/2)\cos(2\mu t)]$ 10)

After expansion the DC and AC components of the unfiltered hearing aid induced signal is

$\varphi_{AM}(DC) + \varphi_{AM}(\mu) = [a_o + a_1 E + a_2 (1 + m2/2) E^2] +$
$[2\,a^2\,m\,E^2\,(\cos(\mu t) + (m/4)\cos(2\mu t))]$ 11)

and for the filtered components

$\psi(t) = H(f)\,P(f)\,\varphi AM(\mu)$ 12)

where

H(f) = hearing aid filtering function and
P(f) = user perceptual filtering function

Equation 11 Conclusions

Equation 11 shows that the strength of the audible output signal (φAM(μ)) is independent of

- the impressed RF frequency
- the modulation frequency

Thus interference power from a multiband handest operating at one band will be the same as when similarly operating in another band, but hearing aid immunity may differ and thus so also might the user experience

The strength of these audible output signal (φAM(μ)) AC signals is dependent upon

- the modulation depth (m),
- the square law second order detector sensitivity coefficient (a_2), and
- the square of the RF field strength amplitude (E)

The latter is the basis for the 2:1 relationship for applying AWF

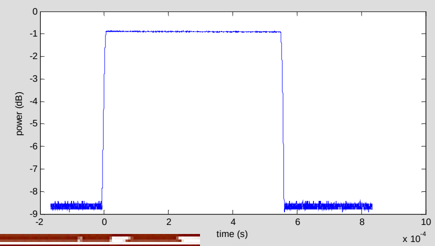
Interference from a handset operating at 2 watts will be 6 dB more than when it is similarly operating at 1 watt

ATIS

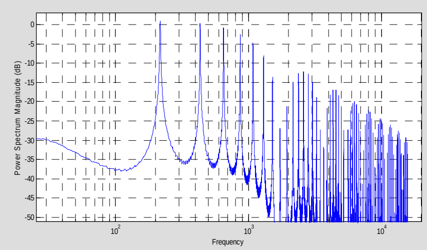
Extension to Other Modulations

- Most cellular transmission protocols utilize a modulation form more complex than that of a single AM modulation tone (μ) applied to a single tone carrier frequency (ω)
- For example the popular ON/OFF keyed constant envelope TDM signal in the time domain can be readily transformed mathematically via a Fourier series of multiple modulating tones in the frequency domain resulting in a series of audible signals that are harmonics of the pulse repetition rate
- When applied to an unmodulated signal this will result in a spectrum of discrete signals that can be mathematically expressed by a series of equations like equations 11 and 12, one for each modulation frequency term in the Fourier series

<u>Time domain (measured)</u> <u>Frequency domain (FFT calculated)</u>



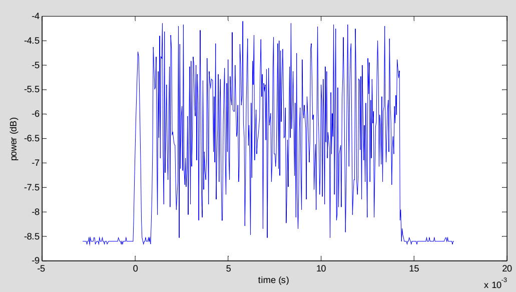
GSM



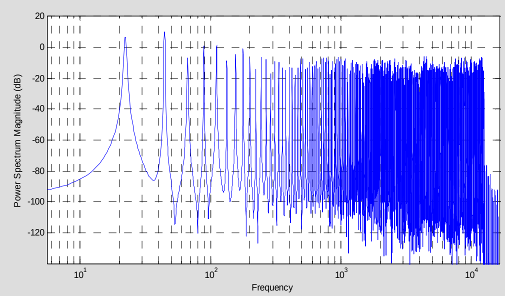
Extension to Other Modulations

- TDM transmission protocols in current use span a nearly 20:1 repetition rate range from a subaudible 11 Hz to a low mid-range 217 Hz
- Below is the audio spectrum of an OFDM like TDM transmission protocol that transmits at a 22 Hz repetition rate a non-constant power envelope using 16-QAM modulation
- This spectrum shows two component types; discrete lines due to the subaudible 22 Hz TDM keying rate, and spread spectrum like components due to pseudorandom variations of the high frequency 4 kHz quad 16-QAM OFDM symbols comprising the power envelope.
- The total amount of power in the *i*DEN signal spectrum is set equal to that in the GSM calculated spectrum

<u>Time domain (measured)</u> <u>Frequency domain (FFT calculated)</u>



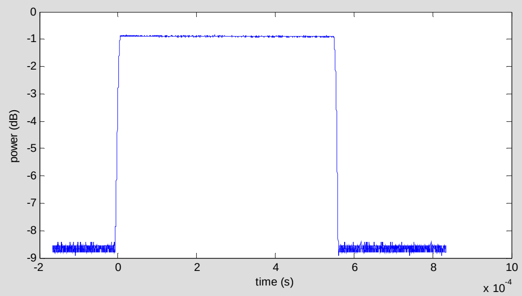
***i*DEN**



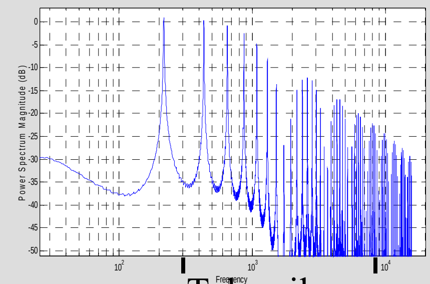
A Modulation Comparison

- The GSM and iDEN spectrograms below are aligned for comparison with lines are drawn between them to illustrate the audio band magnetic (ABM) pass band defined for C63.19 telecoil interference assessment
- For GSM the TDM repetition rate frequency and some high order harmonic components are outside the C63.19 audio interference pass band
- For iDEN the TDM repetition rate frequency, its first 13 harmonic components and some 4 kHz spread spectrum components are outside the audio interference pass band.

Time domain (measured) | Frequency domain (calculated)



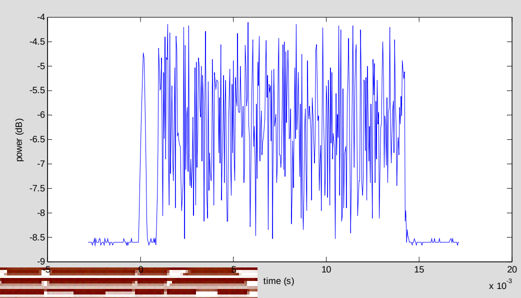
GSM



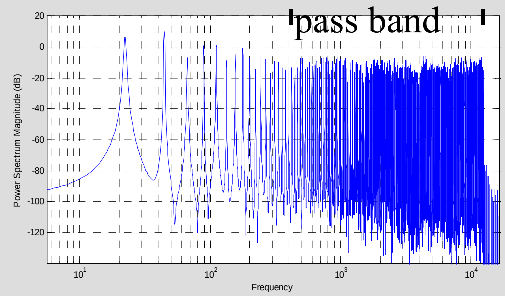
subaudible

Telecoil interference pass band

ultrasonic



***i*DEN**



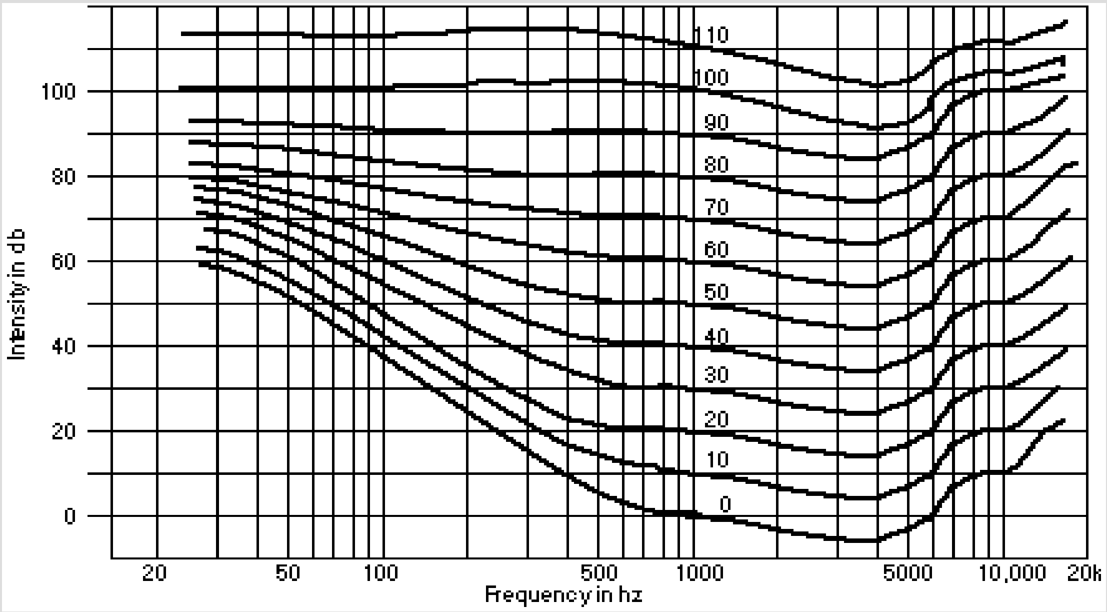
Modulation Comparison

1. Inclusion of the out-of-band audio spectrum components as done using current C63.19 near field assessment methodology results in an underrating of TDM cellular handset M category
2. The underrating results in additional vendor cost and time to market
3. The understatement varies with the transmission protocol and results in a comparative inequity
4. Substantially less interference is expected with the *i*DEN transmission protocol than with GSM
5. Since *i*DEN has more out-of-band power it's more underrated than GSM
6. A band pass filter (H(f) in equation 12) need be employed to appropriately attenuate the out-of-band signals measured to enable correct interference assessment
7. A filter based on the half-band integrator used for telecoil ABM interference may be an appropriate filter
8. All filtering should be included in the C63.19 probe modulation factor
9. Other transmission protocols will be similarly measured and compared
10. Expectations for new transmission protocols can be FFT predicted based on properly filtered power waveform data, and possibly included without a C63.19 committee meeting, and possibly avoid listening tests, if a user perception filter (P(f) in equation 12) can be defined

•

An Example of User Perception

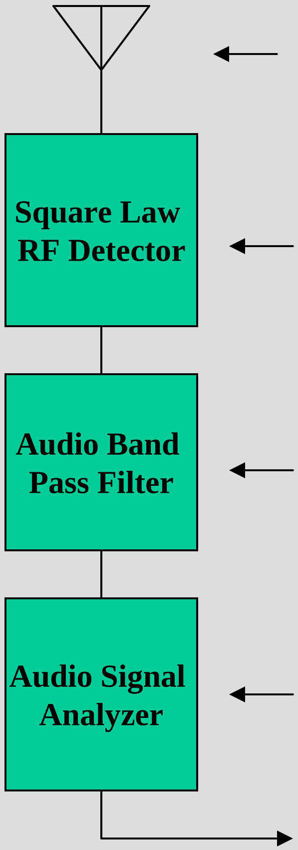
- Fletcher- Munson developed curves based on their work at Bell Labs in the 1930's
- Equal loudness curves for adults with normal hearing were developed in 10 dB phon steps at 1000 Hz
- Curve contours show the sound level required at various audible frequencies to produce a loudness equal to that heard at 1000 Hz.
- Perceptual filter (P(f)) would have an inverse relationship
- Can be readily included with the FFT analysis
- A-weighting filter corresponds to 0 phon level
- Other factors need be considered



Square Law Alternative Test Procedure

- Hearing Aid response to Wireless Device interference is not based upon RF carrier field strengths as currently specified within C63.19 Standard
  - Defining effect on Hearing Aids is based upon
    - Modulation of signals
    - Baseband noise
      - Backlighting
      - Power pulsing
      - Digital circuitry (processor)
- Square Law Test Procedure has the potential to more accurately represent the Hearing Aids response to interference and improve lab testing consistency

Square Law Detector Conceptual Diagram



Antenna or Probe receives modulated RF and all baseband noise

Square Law Detector demodulates RF signal and rectifies baseband noise signals

Audio Band Pass Filter strips all high frequency components while retaining audio band components

Audio Signal Analysis determines magnitude and A/B weighting impacts of interference

Measurement output may constitute either a pass/fail criteria or be assigned a specific M rating

Square Law Detection Benefits

- Promises to more accurately represent the true impact of the full range of Wireless Device interference to the Hearing Aid.
  - Closely mimics the Hearing Aid detection method
  - Captures all interference components (modulation and baseband)
- Combines the impacts of frequency band differences, modulation (AWF and probe modulation factor), peak power issues, and probe response times into a single measurement
- Eliminates the “non-impact” of E & H fields
- Simplified test method reduces uncertainty, complexity, and lab variability

AISP.4 HAC Square Law Alternative Test Procedure Recommendation

- Allow this as an alternative method to meet compliance
- Support addition of Square Law Detection as an alternative test method in the C63.19 Standard

Implementation of C63.19 Enhancements by December 2005

- Support AISP.4 HAC effort to reopen C63.19 Standard as part of the ANSI Public Comment period

- These issues are too high of priority to use core addendums, amendment, or other procedures

Contact Sheet

Tom Goode
Attorney
ATIS
tgoode@atis.org

Jim Turner
Technical Coordinator
ATIS
jturner@atis.org

Al Wieczorek
Distinguished Member of the Technical Staff
Motorola
al.wieczorek@motorola.com

Mel Frerking
Director of WTS
Cingular Wireless
mel.frerking@cingular.com